Offset-fed UWB Antenna with Multi-slotted Ground Plane

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ABSTRACT: This paper presents the design and results of an offset feed Ultrawideband(UWB) antenna with a multiple-slotted ground plane. The antenna consists of a square shaped radiator, a feed slightly offset from the middle along the radiator side and a ground plane with multiple rectangular slots. Simulation results show that the antenna can achieve a wide bandwidth from 3.3 to 18 GHz.

1. INTRODUCTION

Broadband and multiband antennas play strong roles in the wireless communications world because of the increasing demand of high data transmitting rates. Ultra-wideband (UWB) technology, due to the advantages of low cost, low complexity, low spectral power density, high precision ranging, low interferences and extremely high data rates, has attracted much attention. Since the Federal Communications Commission (FCC) allocated 7.5 GHz spectrum from 3.1 to 10.6 GHz for UWB radio applications in 2002 [1], UWB antennas, as a key component in UWB system, have been widely investigated by many researchers [2-9]. However, the design of efficient and compact size antennas for wideband applications is still a major challenge. Many microstrip-fed and coplanar waveguide-fed antennas have been reported for UWB applications [2-9]. These antennas employed either the monopole configuration with different shapes (circular ring, ellipse, annual ring, triangle, pentagon or hexagon) or the dipole configuration (e.g. the bow-tie antennas) [2-9]. Some of these UWB antennas did not have planar structures (i.e., their ground planes were perpendicular to the radiators). As a result, these antennas cannot be easily integrated with the printed circuit boards.

Numerous methods can be used to increase the bandwidth of UWB antennas, e.g. using thicker substrate or substrates with lower dielectric constants, employing various feeding techniques and using slot antenna geometry [10,11]. However, the bandwidth and the size of an antenna are generally mutually conflicting. Improving one characteristic normally results in degrading the other.

Different techniques can be used to increase the impedance bandwidths of the circular and elliptical planar monopole antennas, e.g. inserting an additional stub to the one side of the circular patch [12], increasing the elliptically ratio of ellipse-shaped patch [4], adding slot to one side of the radiating element [13] and adding steps to the lower edge of the patch [14]. The square shaped antenna fed by a microstrip line, which has the planar configuration, is a good candidate for wideband applications.

In this paper, a wideband antenna that consists of a square shaped radiator, a feed line slightly offset from the middle along the side of the radiator and a ground plane with rectangular slots is proposed. Results show that the proposed antenna can achieve a bandwidth from 3.3 GHz to 18 GHz with Voltage-Standing-Wave Ratio (VSWR) ≤ 2 and nearly omnidirectional radiation patterns almost over the entire UWB band.

2. ANTENNA STRUCTURE

The geometry of the proposed antenna is shown in Fig. 1. It consists of a square shaped radiator with an offset feed line and a partial ground plane with rectangular slots. The antenna is fabricated on a low cost FR4-substrate with a thickness of 1.6 mm, a relative permittivity of 4.6 and a total size of $W \times L$. The square shaped radiator has an area of $W_P \times L_P$ and the microstrip-fed line is printed on one side of the substrate. The width of the microstrip-fed line is fixed at w_m to achieve 50Ω characteristics impedance. A SMA connector is connected to the port of the microstrip-fed line. The partial-ground plane with a length of l_m is printed on the other side of the substrate. Some rectangular slots with dimensions 2mm× 1mm and 6mm × 1mm are added to

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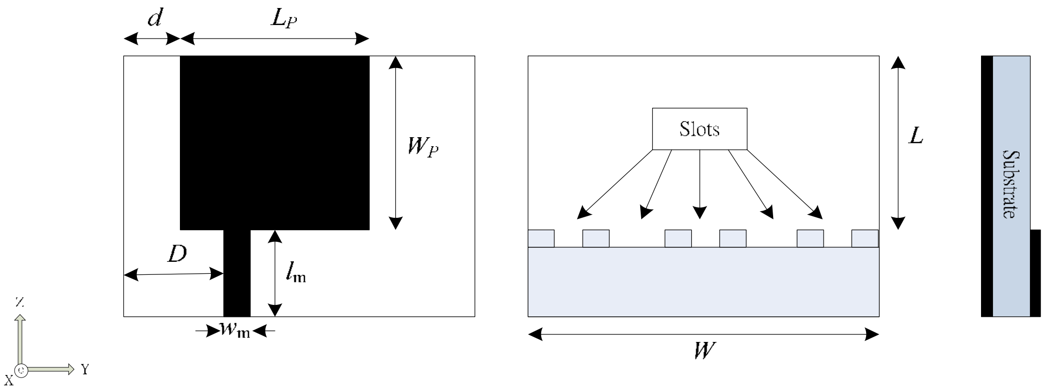
the top side of the finite-ground plane to adjust the input impedance characteristics. The antenna has the following parameters: W = 30 mm, L = 22 mm, W_P = 14.5 mm, L_P = 14.75 mm, D = 6mm, d = 3mm, w_m = 2.6 mm and l_m = 7.25 mm. The geometric parameters of this structure can be adjusted to tune the return loss and bandwidth over a wide range of frequency. The square-shaped radiator is capable of supporting multiple resonant modes and hence to provide a wider impedance bandwidth. The slots on the partial-ground plane can be used for improving matching, e.g. by increasing the gap between the radiating element and ground plane. As a result, the bandwidth is increased and the size of the ground plane is reduced.



(a) Top View (b) Bottom View (c)Side View

Fig. 1 Geometry of antenna

3. RESULTS AND DISCUSSIONS

The geometry of proposed antenna has been optimized using the EM simulation tool, CST MS 2009 [15]. The antenna has also been prototyped for verification. Fig. 2 shows the simulated and measured return losses of the antenna. The proposed antenna has an impedance bandwidth from 3.3 to 18 GHz. The discrepancy between simulation and measurement is mainly due to the solder and inaccuracies during fabrication. Fig. 3 shows the peak gain of the antenna in the frequency range from 1 to 18 GHz. The antenna has a maximum gain of 5.2 dBi at 10.1 GHz with an average gain of 2.96 dBi. The radiation efficiency of the proposed antenna is shown in Fig. 4. The antenna has a maximum radiation efficiency of 91.3% with an average of 61.7% through the whole bandwidth. At low frequency, the low radiation efficiency of the antenna is due to the high return loss as shown in Fig. 2. At high frequency, the low readiation efficiency is due to the high losses in FR4 substrates.

Fig. 5 shows the radiation patterns of the proposed antenna at three frequencies, 4.5, 10.2 and 18 GHz. It can be seen that the H-plane radiation patterns are almost omnidirectional. The E-planes radiation patterns at 4.5, 10.2 and 18 GHz do not have obvious null which is very different from a normal monopole antenna. This is due to the antenna being offset fed.

4. CONCLUSIONS

An offset-fed antenna with a multiple-slotted ground plane has been designed and proposed for UWB applications. The antenna has a compact size of 30 mm × 22 mm and is simple and very easy to be integrated with microwave circuitry for low manufacturing costs. The use of rectangular slots on the top side of the partial-ground plane not only improves the impedance matching but also the radiation characteristics in the high frequency band. The antenna can achieve an impedance bandwidth from 3.3 to 18 GHz with nearly a constant peak gain. The radiation patterns in the H-plane are almost omnidirectional over the entire frequency band. There is no obvious null observed in the radiation patterns in the E-plane. The stable radiation patterns and constant peak gain make the proposed antenna suitable for use in UWB communication systems.

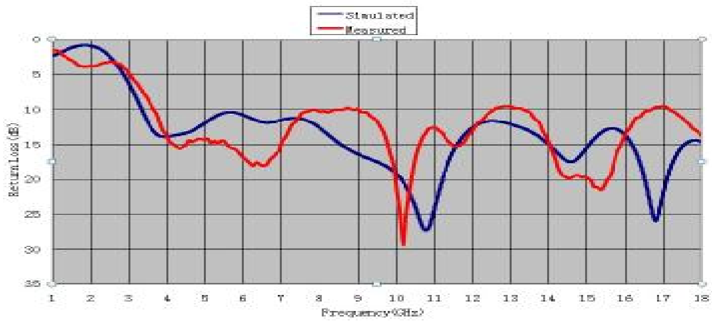


Fig. 2 Simulated and measured return losses

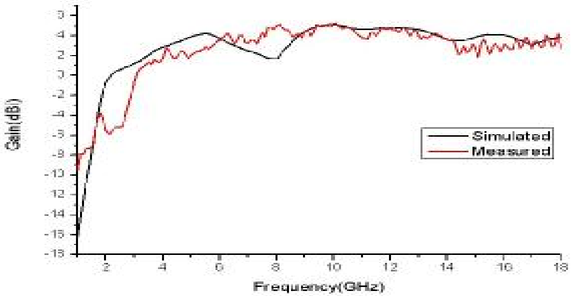


Fig. 3 Peak gain

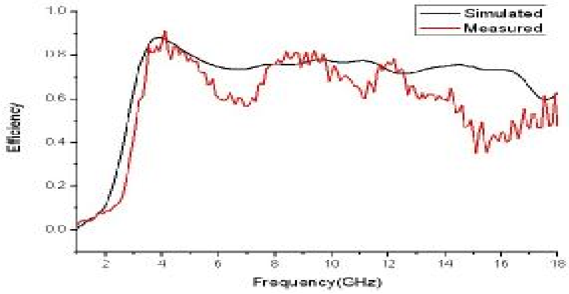
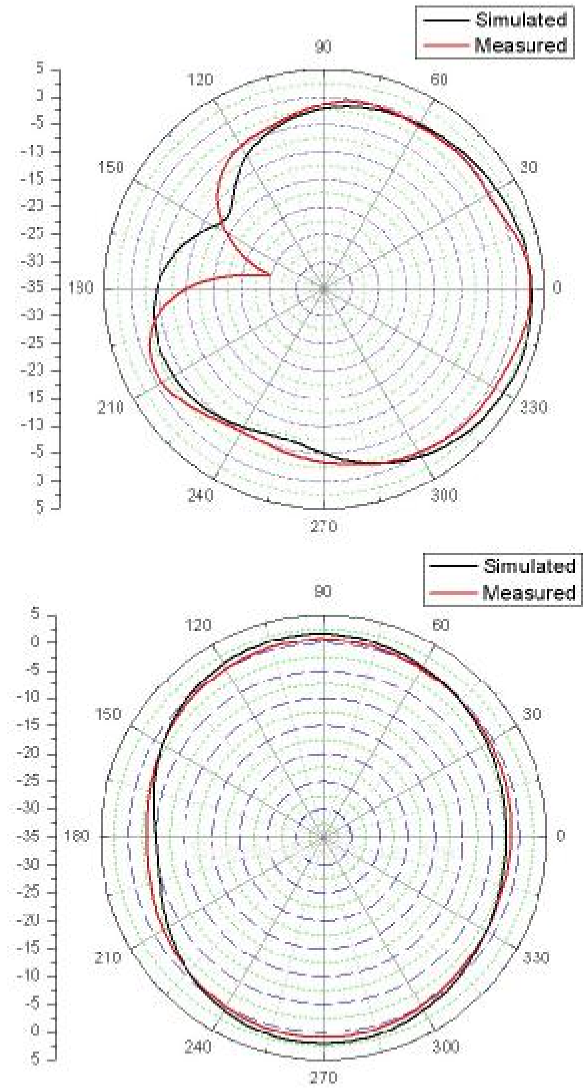
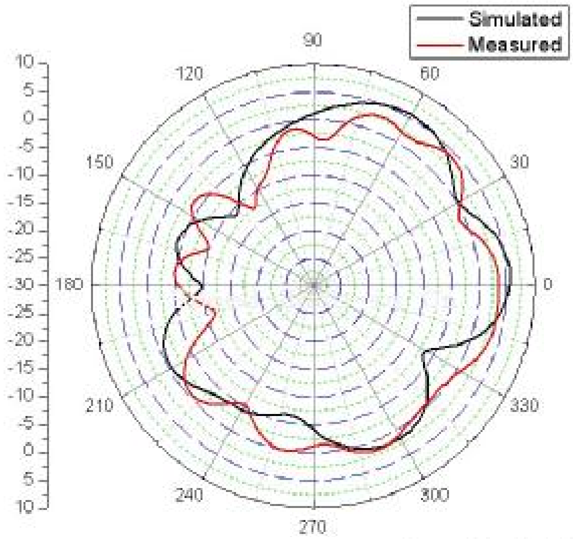
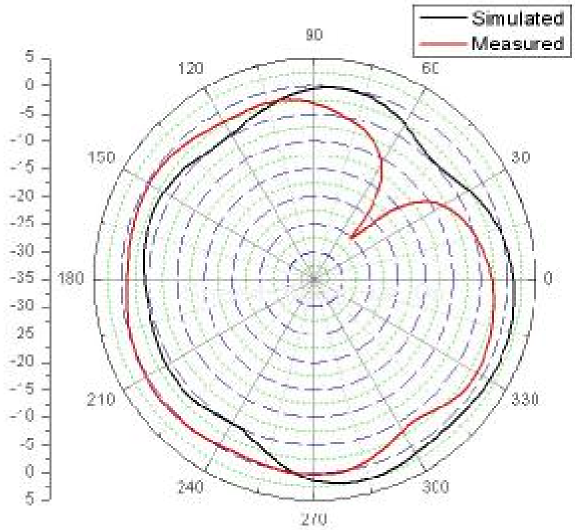


Fig. 4 Radiation efficiency

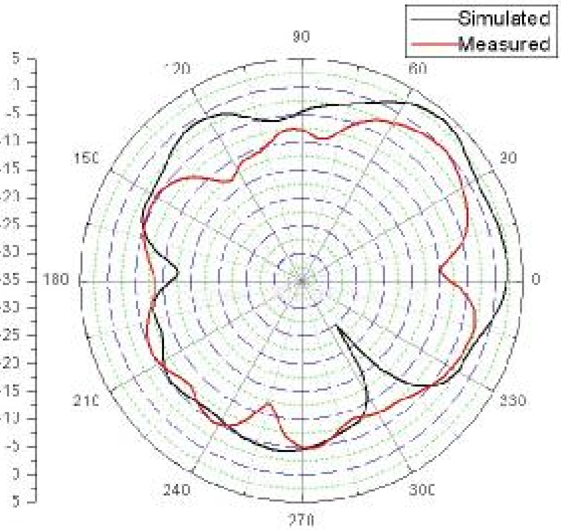


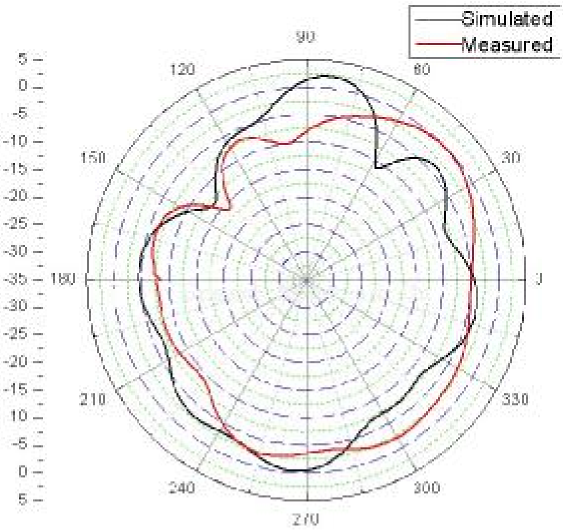
(a)



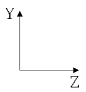


(b)





E-plane **(c)** **H-plane**



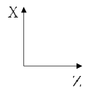


Fig. 5 Radiation pattern at (a) 4.5 GHz, (b) 10.2 GHz, and (c) 18 GHz

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